Geology

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Objectives:

To gain an understanding of the geological situations in which hydrocarbons form.

This will enable you to understand why petroleum exists in certain countries and not in others?.

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At the end of this Session, you will be able to:

- Name the three main rock types and identify which one is most important in petroleum geology.
- List 2 examples of each of the three main rock types.
- Define the terms erosion, sandstone & carbonate rocks.
- Define the term sedimentary basin
- Define the following stages in the formation of hydrocarbons decomposition, sedimentation, motion, maturation, migration and trapping
- Define the term hydrocarbon.
- List the temperatures at which oil and gas formation occurs.

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Igneous Rocks

Igneous rocks were formed by the cooling and subsequent solidification of a molten mass of rock material, known as magma.

Plutonic rocks are formed by intrusive slow cooling of magma resulting in coarse grained rocks eg gabbro, granites

Volcanic rocks are formed by extrusive rapid cooling of magma resulting in fine grained rocks eg basalts, rhyolites

Composed of silicate minerals, they are either classified as acid (granite, rhyolite) or basic (basalt, gabbro)

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Igneous Rocks

Igneous rocks are generally not of interest to the petroleum geologist.

Granite

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Metamorphic Rocks

Rocks whose composition and texture has been altered by heat and pressure deep within the Earth's crust.

Metamorphism occurs to both igneous or sedimentary rocks, where the resultant rock depends on the amount of heat and pressure they have been subjected to. Generally metamorphosis makes the rocks more compact and harder

- **Shales become Slate in lower temperatures or Phyllite in high temperatures at even higher temperatures it forms gneiss or schist**
- **Sandstone become Quartzite**
- **Limestone becomes Marble**

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Metamorphic Rocks

Metamorphic rocks are generally not of interest to the petroleum geologist.

Quartzite

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Sedimentary Rocks

Sandstones are formed from the erosion (weathering) of other rock types, the weathered debris is transported and deposited in various forms of rocks like conglomerates, sandstones and shales.

Organic material gets trapped during this process. Oil and gas!

Carbonates form in a marine environment where an abundance of calcium carbonate secreting organisms, including certain algae, corals and animals with shells, can give rise to limestone and dolomite

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Sedimentary Rocks

Limestones, sandstones, and dolomites are good reservoir rocks. Shales are good source rocks, as well as a good seal

Sedimentary outcrop

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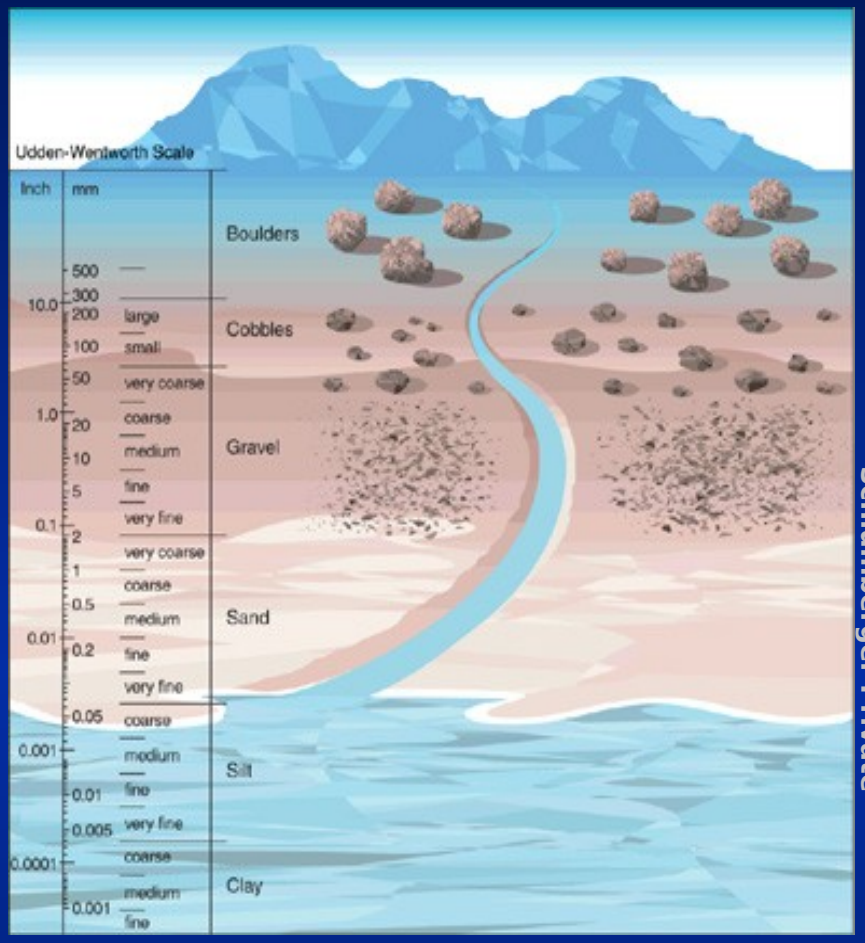
Erosion

The process of denudation of rocks, including physical, chemical and biological breakdown and transportation.

Once the rock has been broken down by the above processes it can then be transported by wind, water, ice, or abrasive solid particles, or by mass-wasting, as in rock falls and landslides.



As rocks and sediments are eroded and transported down slopes, larger grains settle out and smaller grains are carried farther as

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SEDIMENTARY BASINS

Sedimentary basins are depressions on the earth's surface with a sedimentary column between 2 km and 10 km.

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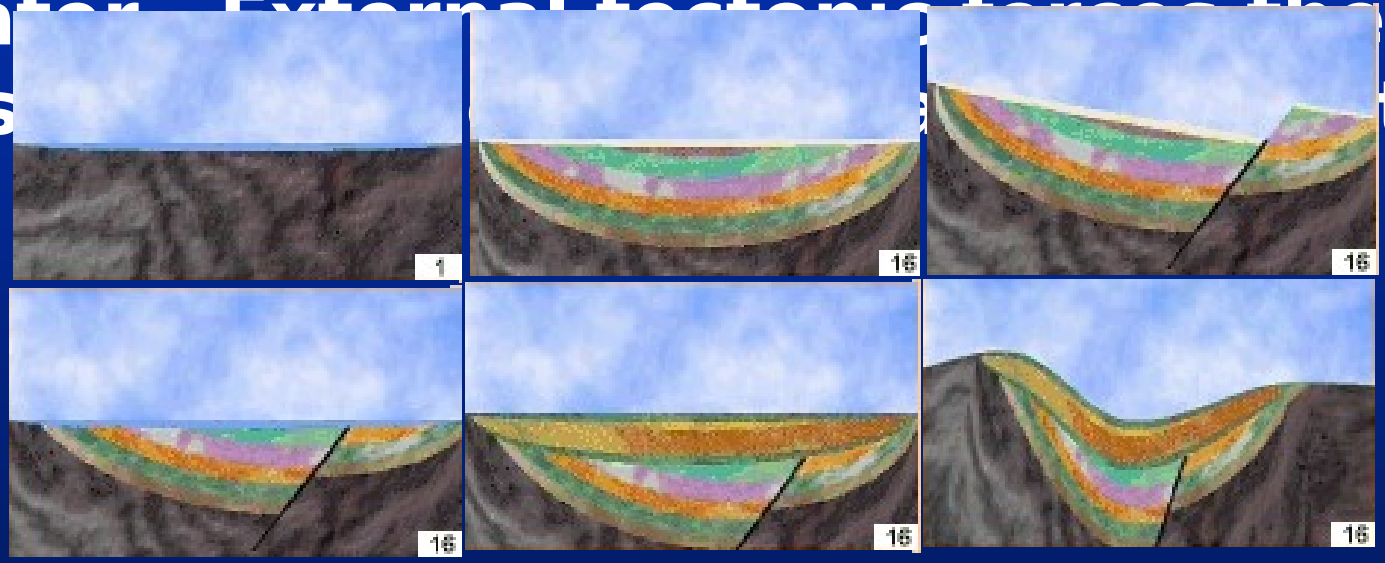
Sedimentary Basins

Sedimentary basins were formed over hundreds of millions of years by the action of the deposition of eroded material and the precipitation of chemicals and organic matter in the sea wa External tectonic forces th dis ta.



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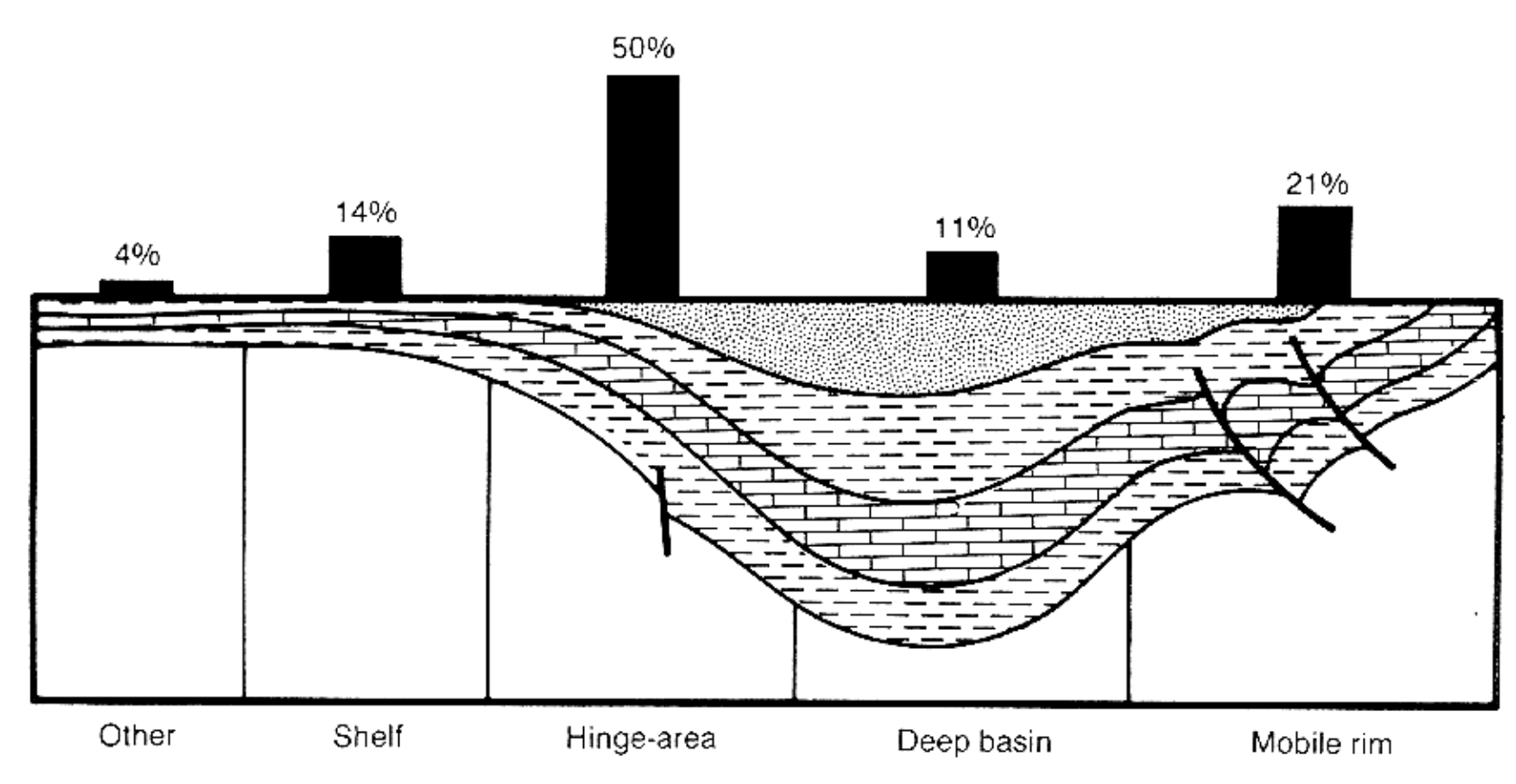
Major sites of petroleum accumulation



percentage of world's occurrence from various locations.

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Sedimentary Basins Around the World

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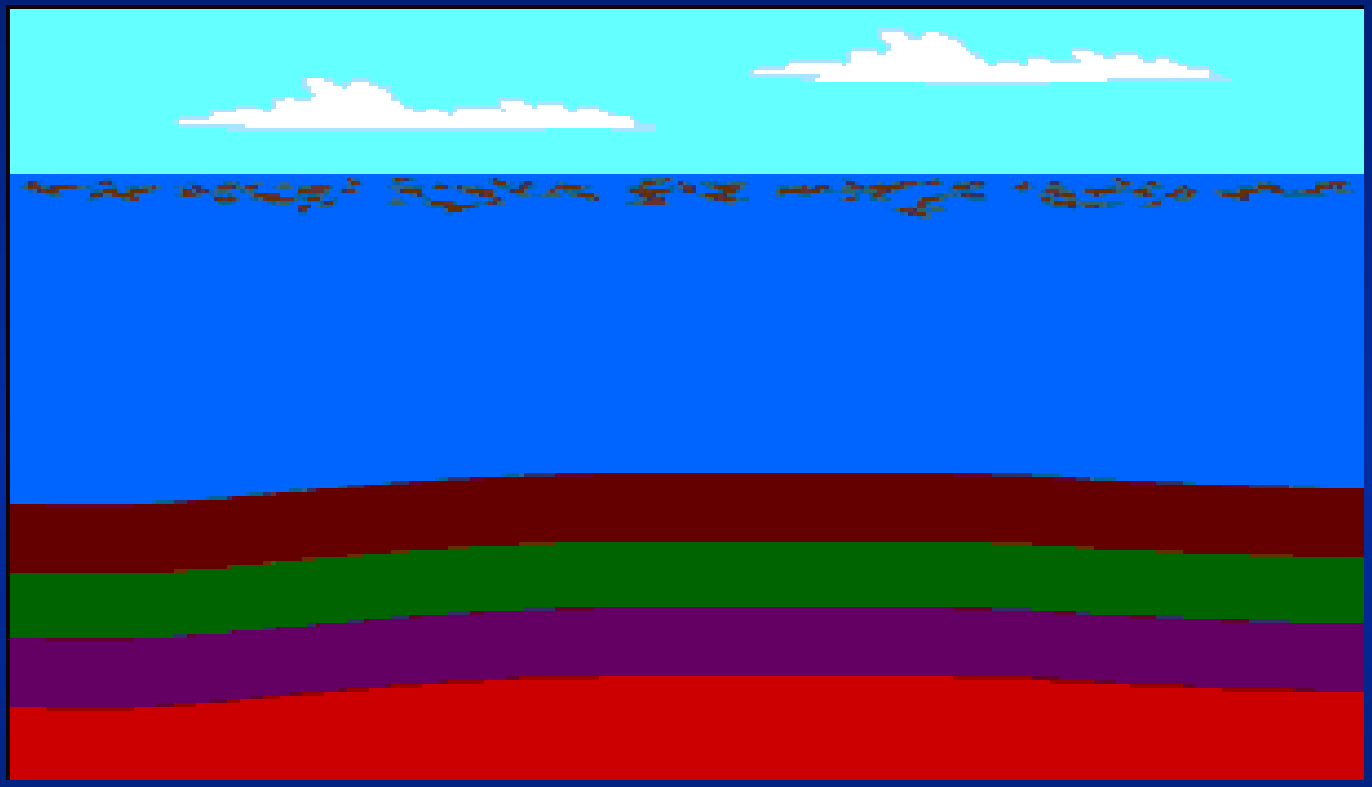
Decomposition



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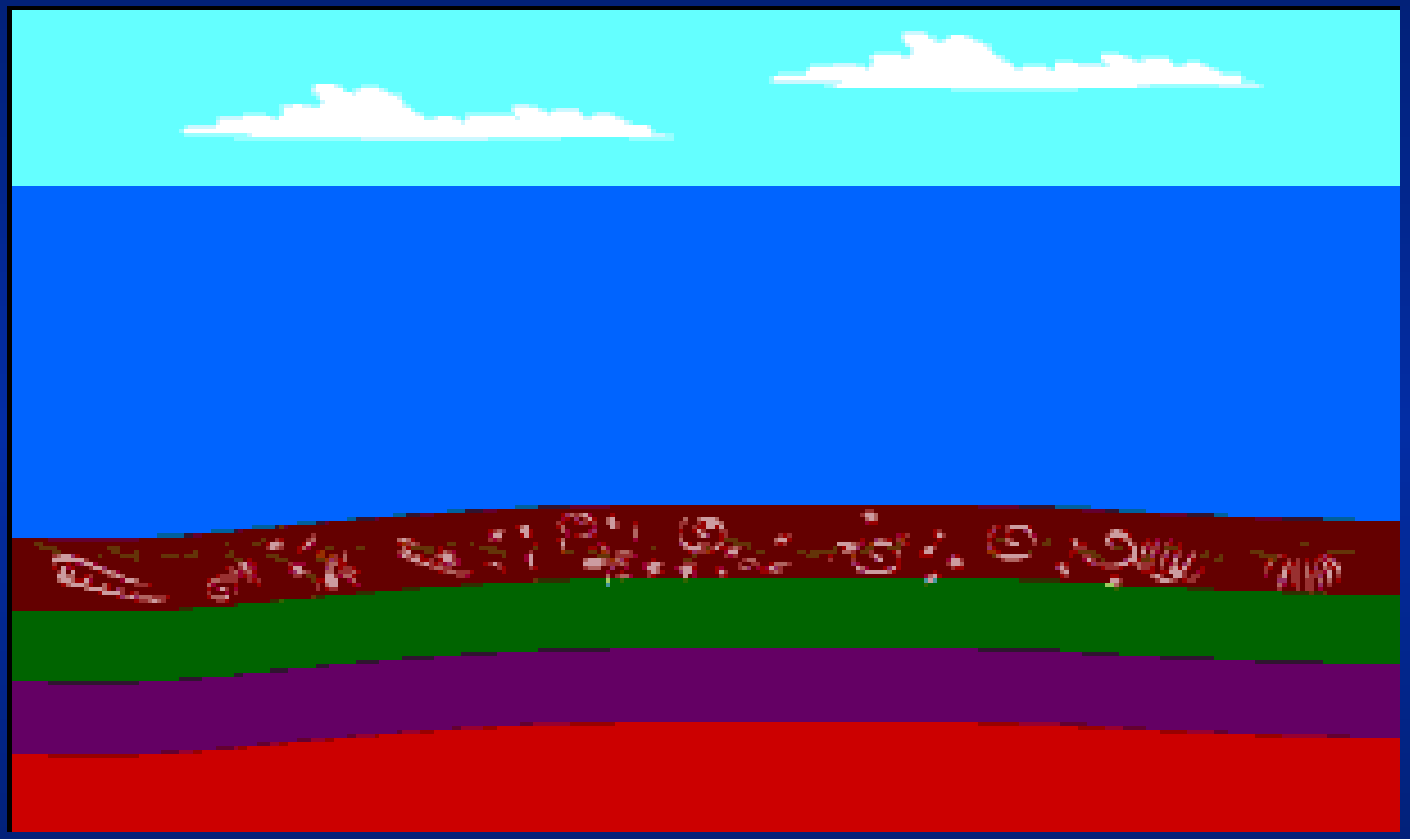
Sedimentation



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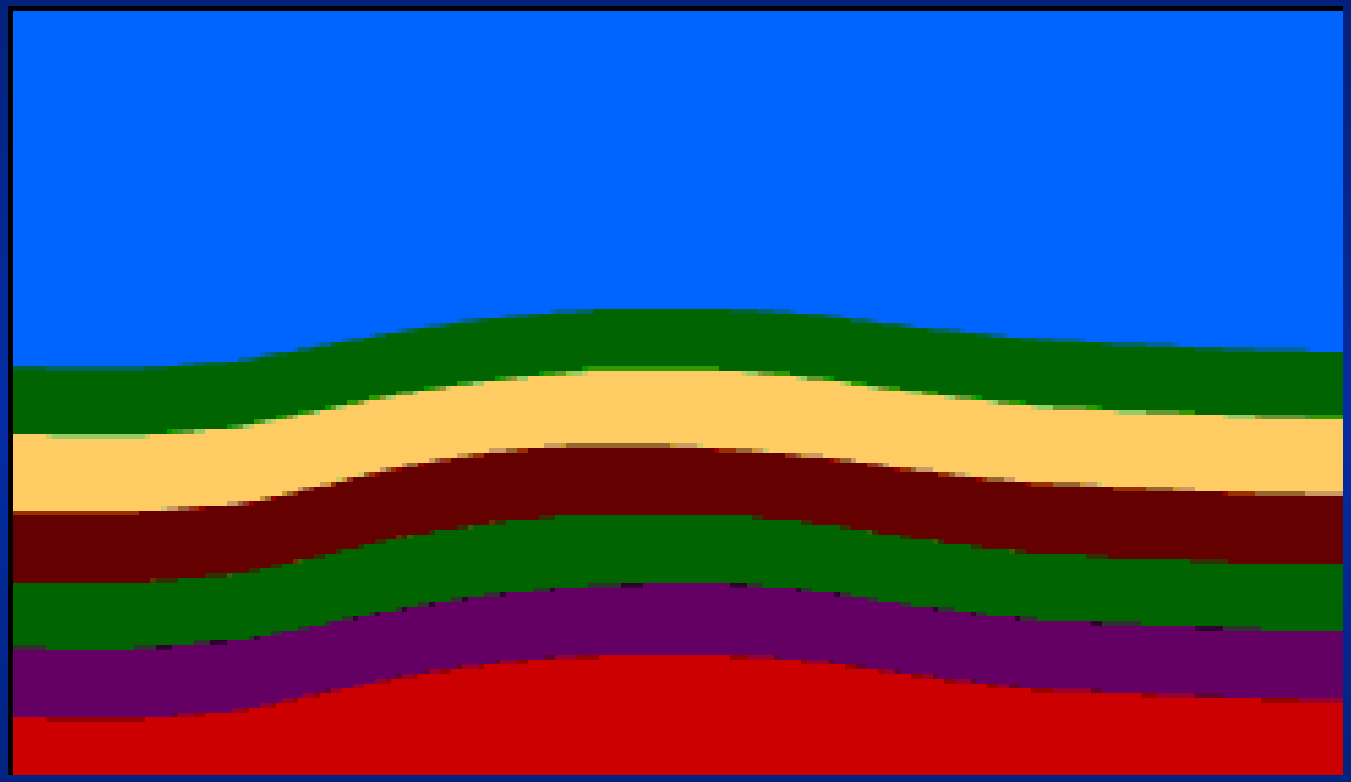
Motion



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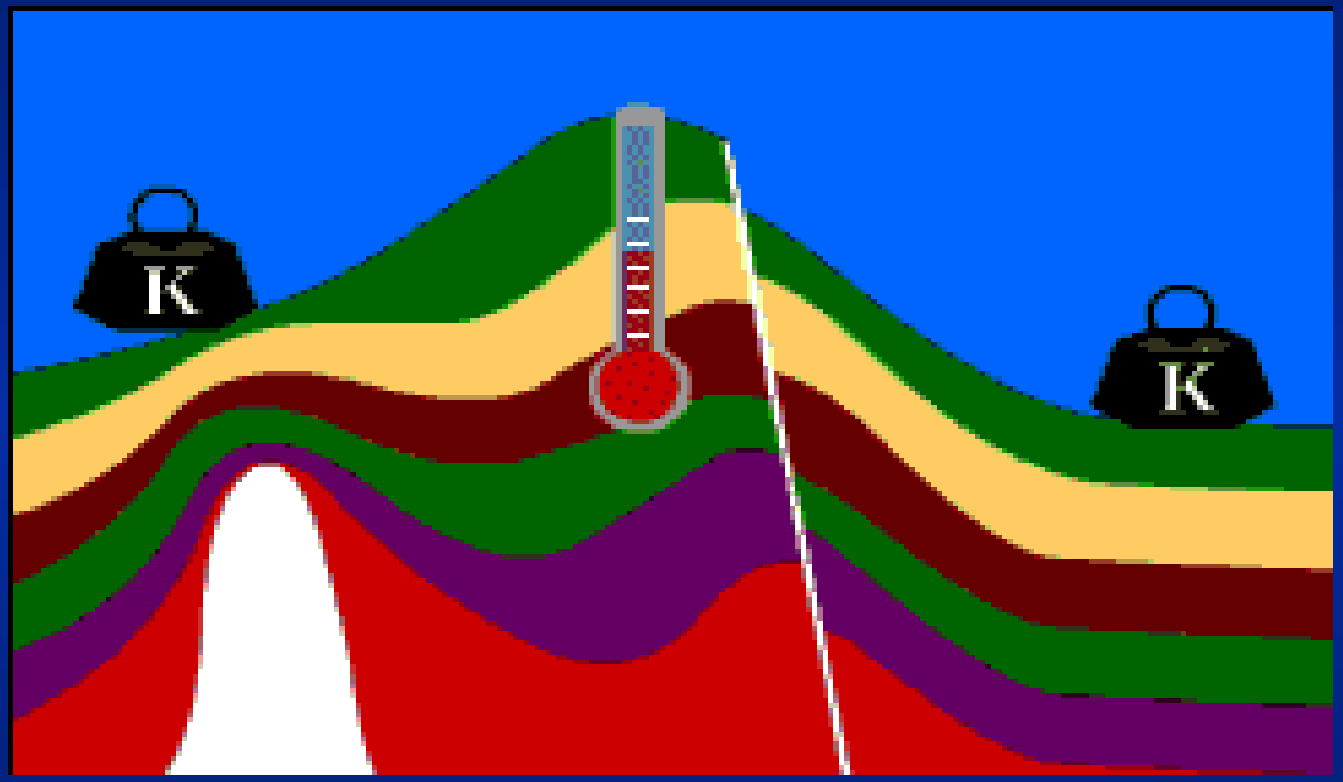
Maturation



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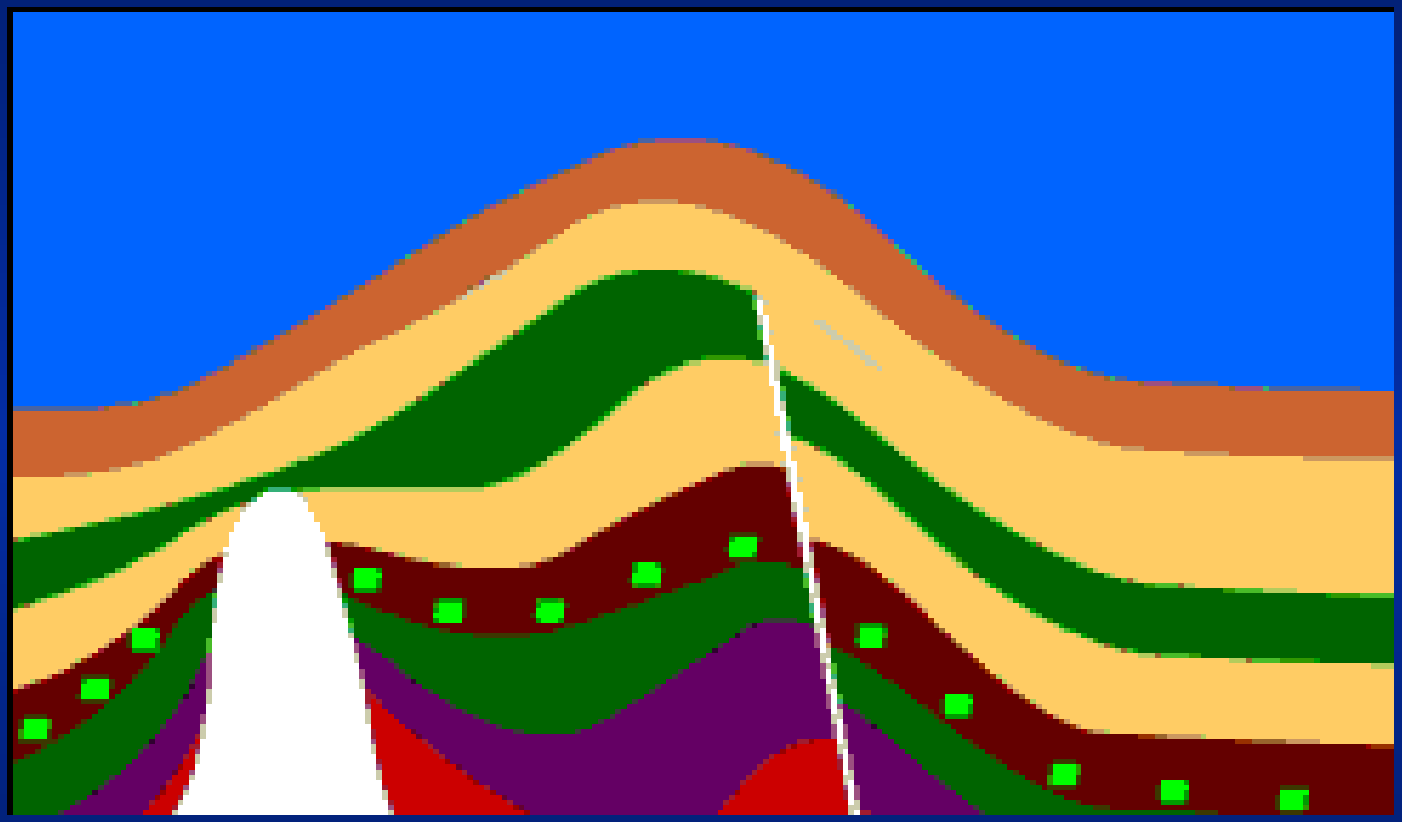
Migration



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Trapping

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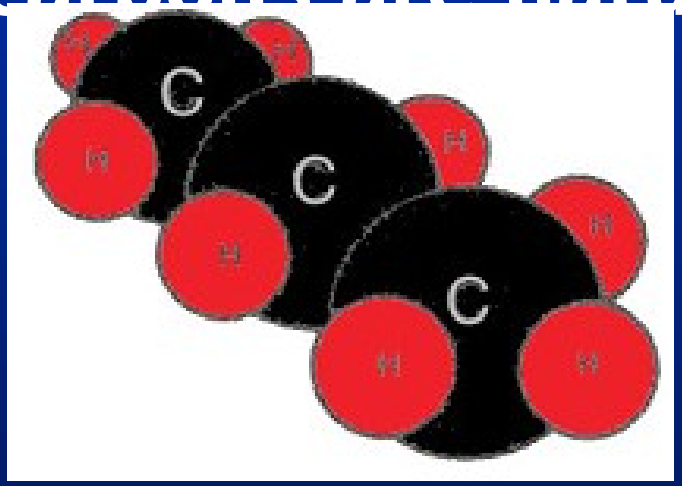
Hydrocarbons

A naturally occurring organic compound comprising hydrogen and carbon. Hydrocarbons can occur as gases, liquids or solids. The molecules can have the shape of chains, branching chains, rings or other structures. The most common hydrocarbons are natural gas, oil and coal.



Propane

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Petroleum Generation

- Petroleum is generated when Kerogen (type of hydrocarbon) is subjected to increase in Temperature.
- The oil window is between 60-175 ℃.
- The wet gas window is between 175-225 ℃.
- The dry gas window is between 225-315 ℃.
- Thermal gradient is responsible for

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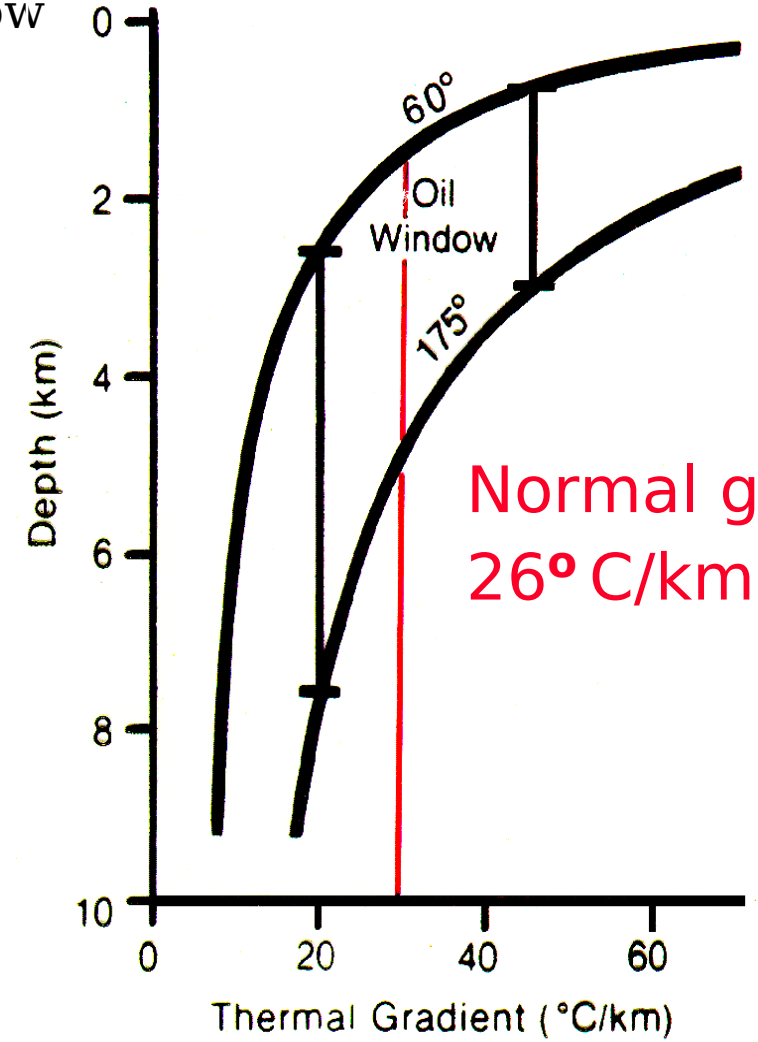
Geothermal gradient

Oil Window

Range & width



Normal gradient
26° C/km

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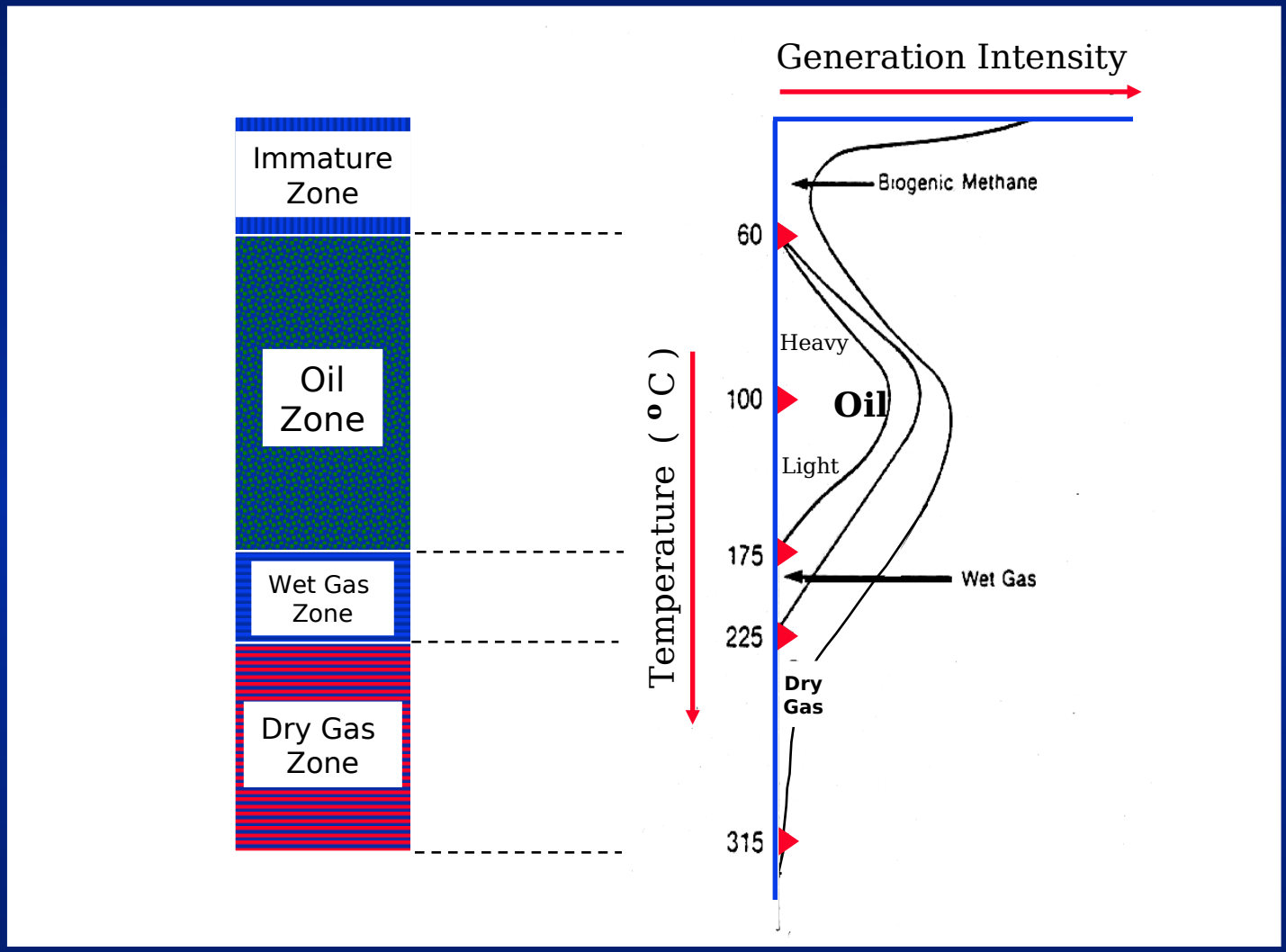
Oil –Gas Windows



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Factors needed for Petroleum Accumulation

There are five important factors need to have Petroleum

forming a commercial product.

1. Source Rock
2. Migration of Petroleum
3. The Reservoir (Migrated from source to Reservoir)
4. A Trap (Geologic Structure)
5. A Seal (an Impermeable Rock)

If one of these factors is not fulfilled, no commercial

accumulation will result.

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Source Rock

A rock rich in organic matter which, if heated enough, will generate oil or gas.

Typical source rocks, usually shales or limestones, contain about 1% organic matter and at least 0.5% total organic carbon (TOC), although a rich source rock might have as much as 10% organic matter.

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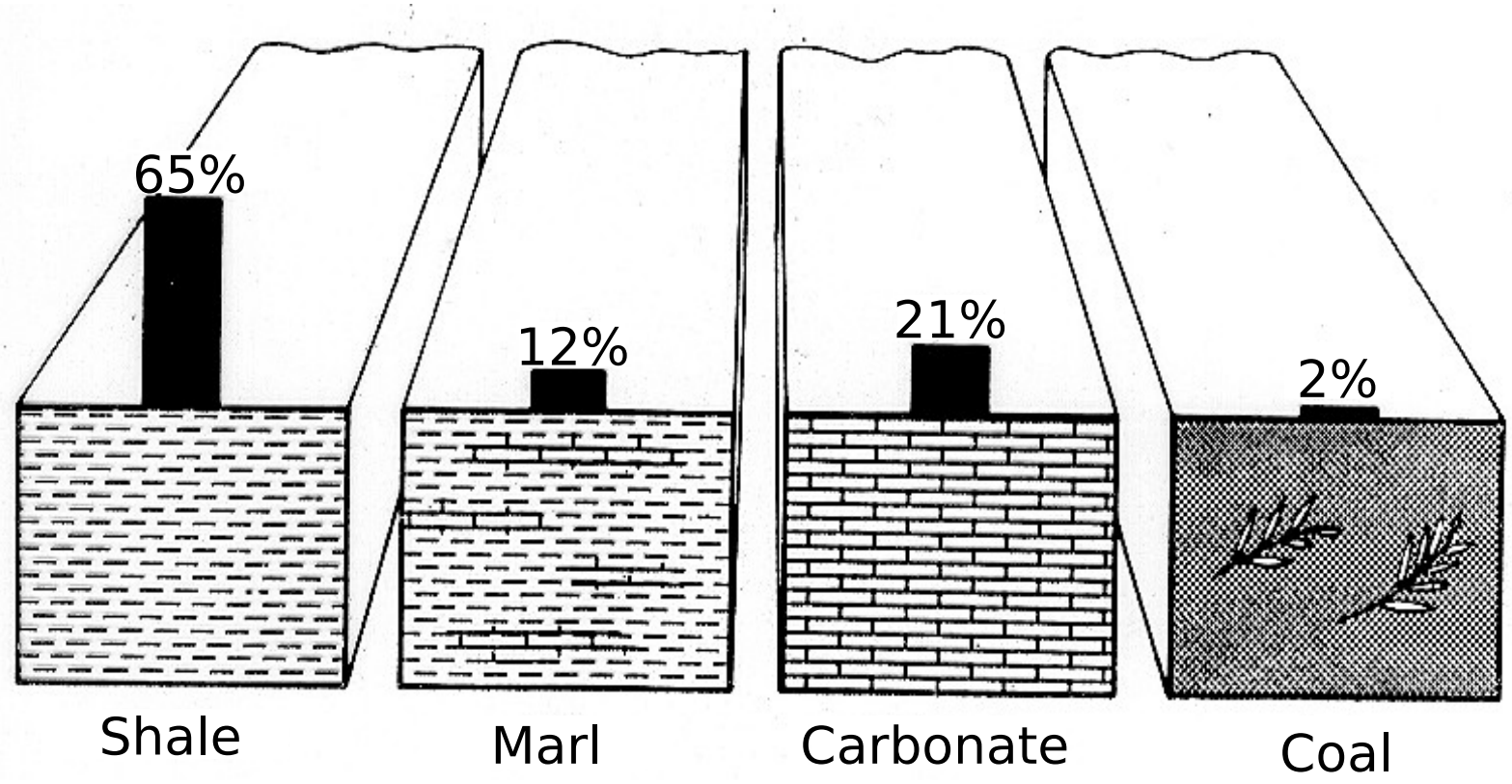
World's Petroleum Occurrence As Source Rocks



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Reservoir Rock

A subsurface body of rock having enough porosity and permeability to store and transmit fluids.

Sedimentary rocks are the most common reservoir rocks because they have more porosity than most igneous and metamorphic rocks and form under temperature conditions at which hydrocarbons can be preserved.

Rock types which makes good reservoirs are sandstone, limestone and dolomites

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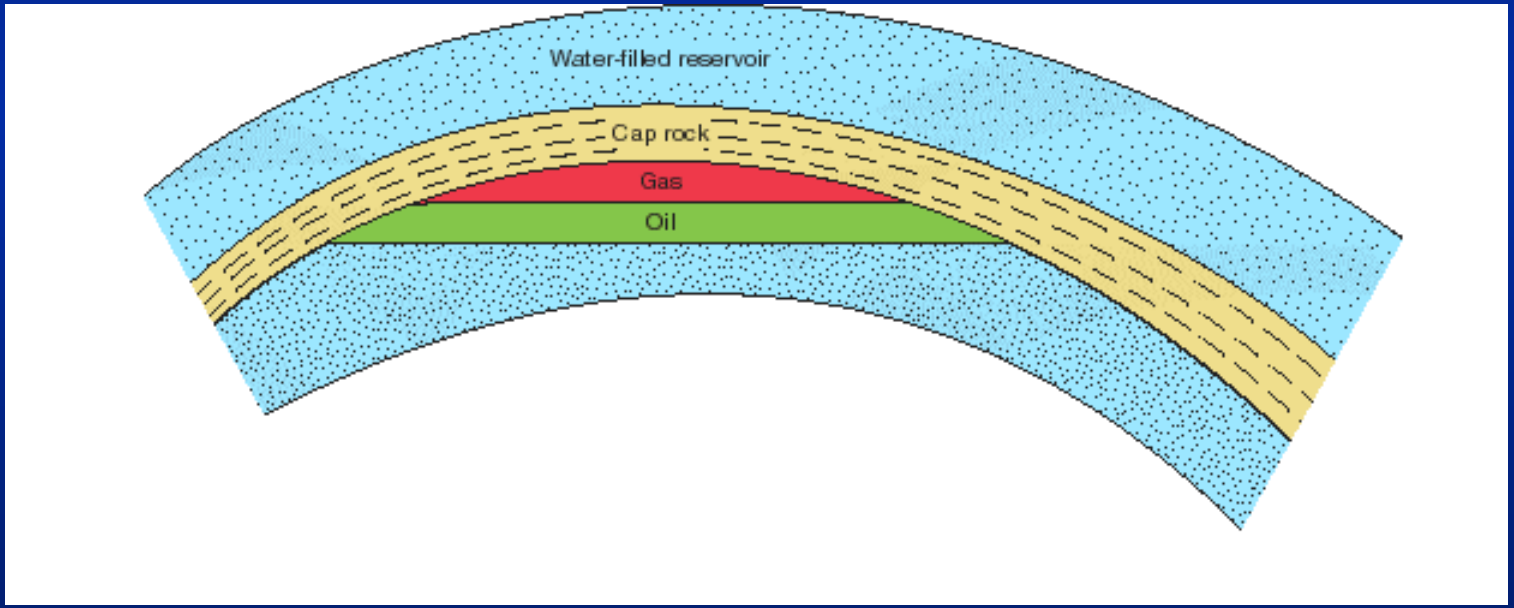
Cap Rock

A relatively impermeable rock, usually shale, anhydrite or salt, that forms a barrier or seal above and around reservoir rock so that fluids cannot pass beyond the reservoir.



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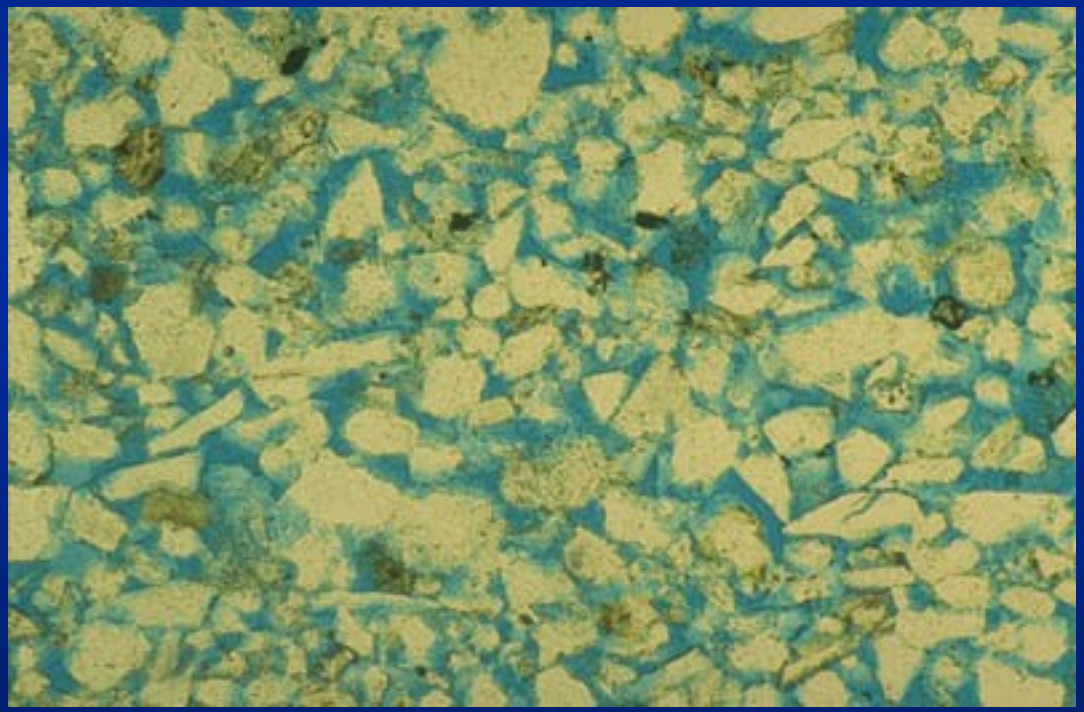
Porosity

The percentage of empty space in a rock, or that volume within rock that can contain fluids.



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Permeability

The measurement of a rock's ability, to allow fluids to move through them.

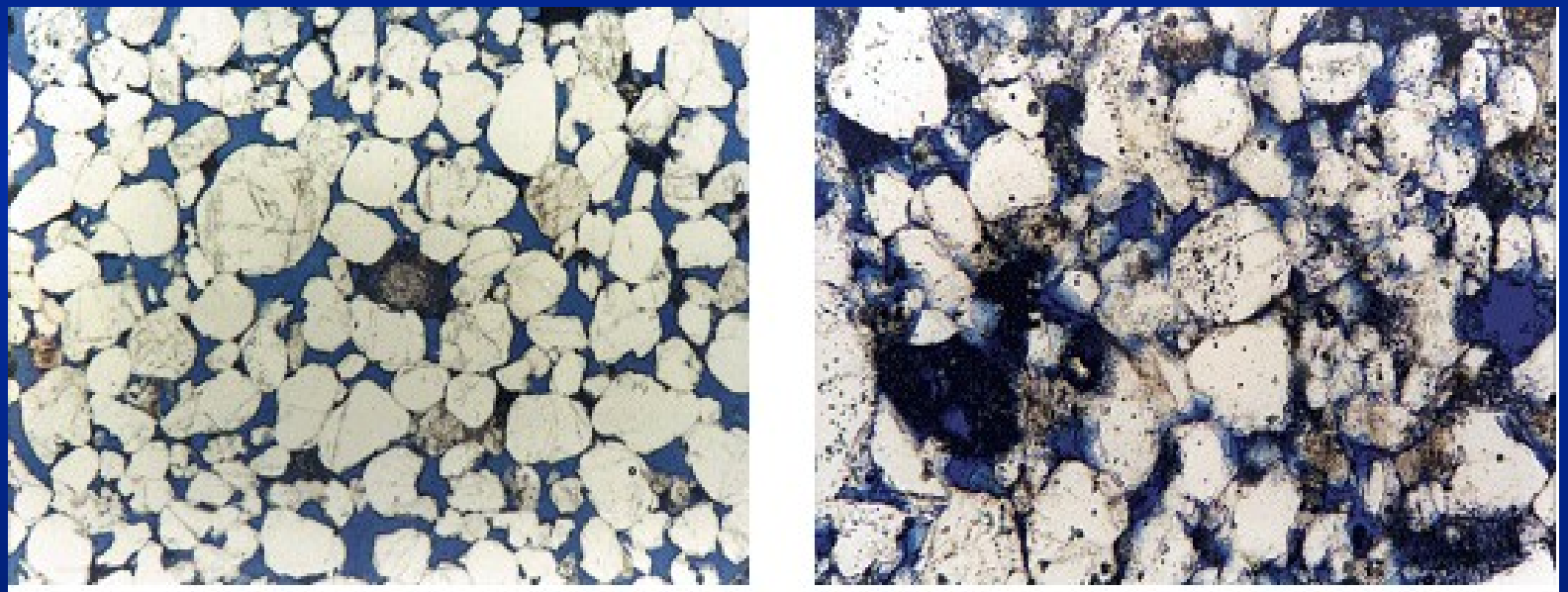

Fig 1 1 A core sample with high permeability to the left and low permeability to the right. Notice the oil accumulations due to low permeability.

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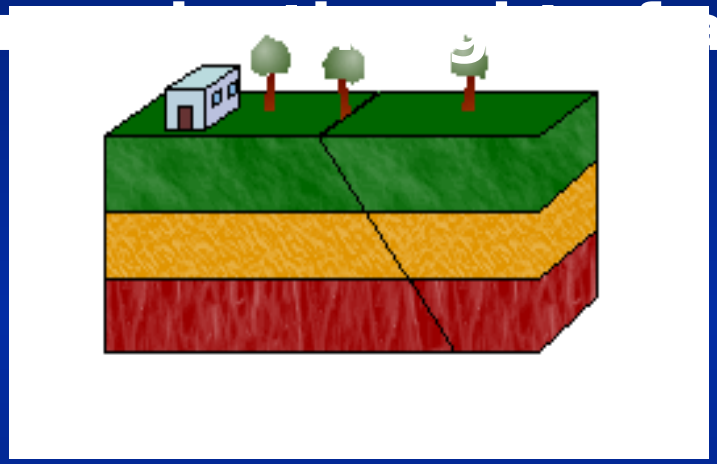
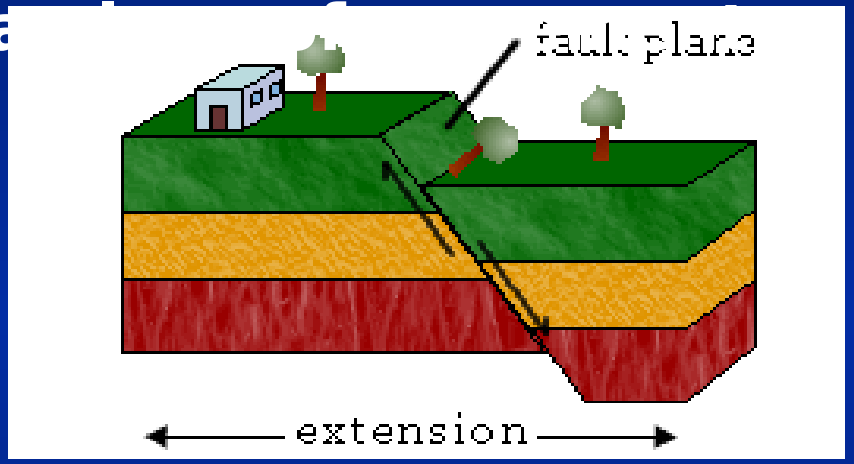
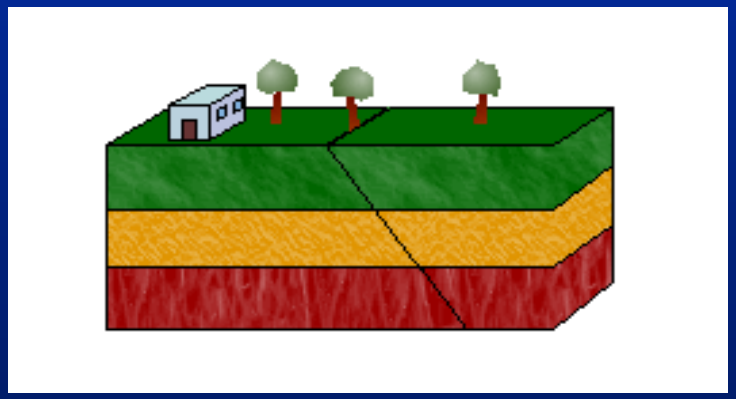
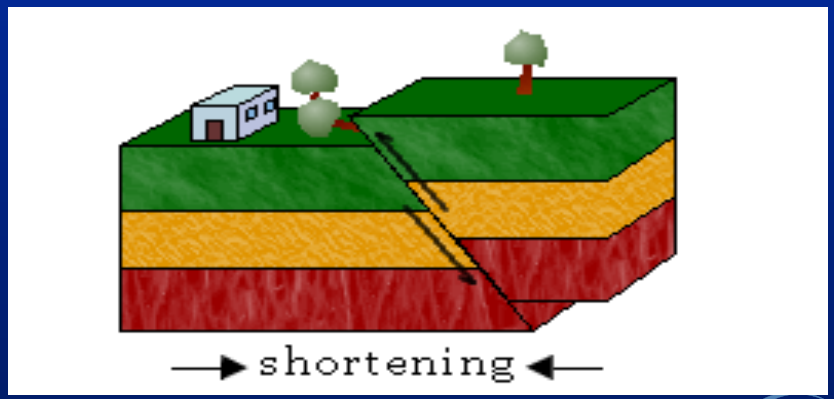
Geologic Structures..Faults

A fault is a surface or zone along which one side of a rock body has moved relative to the other. It









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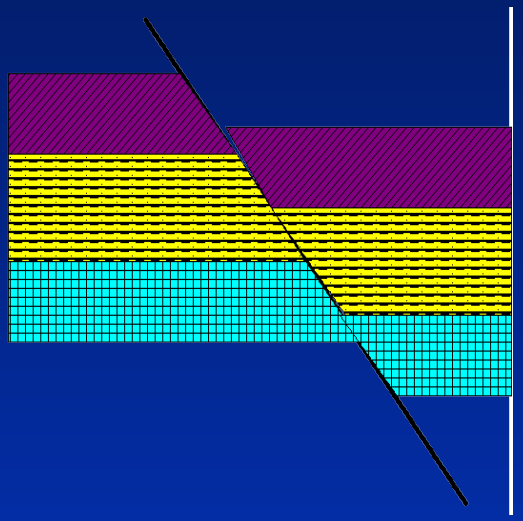
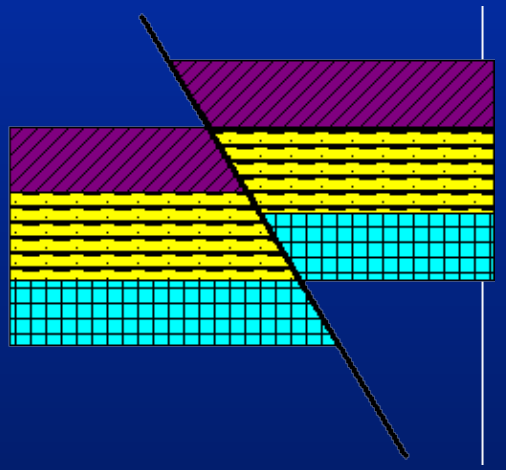
Types of faults

Normal fault: the hanging wall moves down relative to the footwall



Reverse or Thrust fault: the hanging wall moves up relative to the footwall



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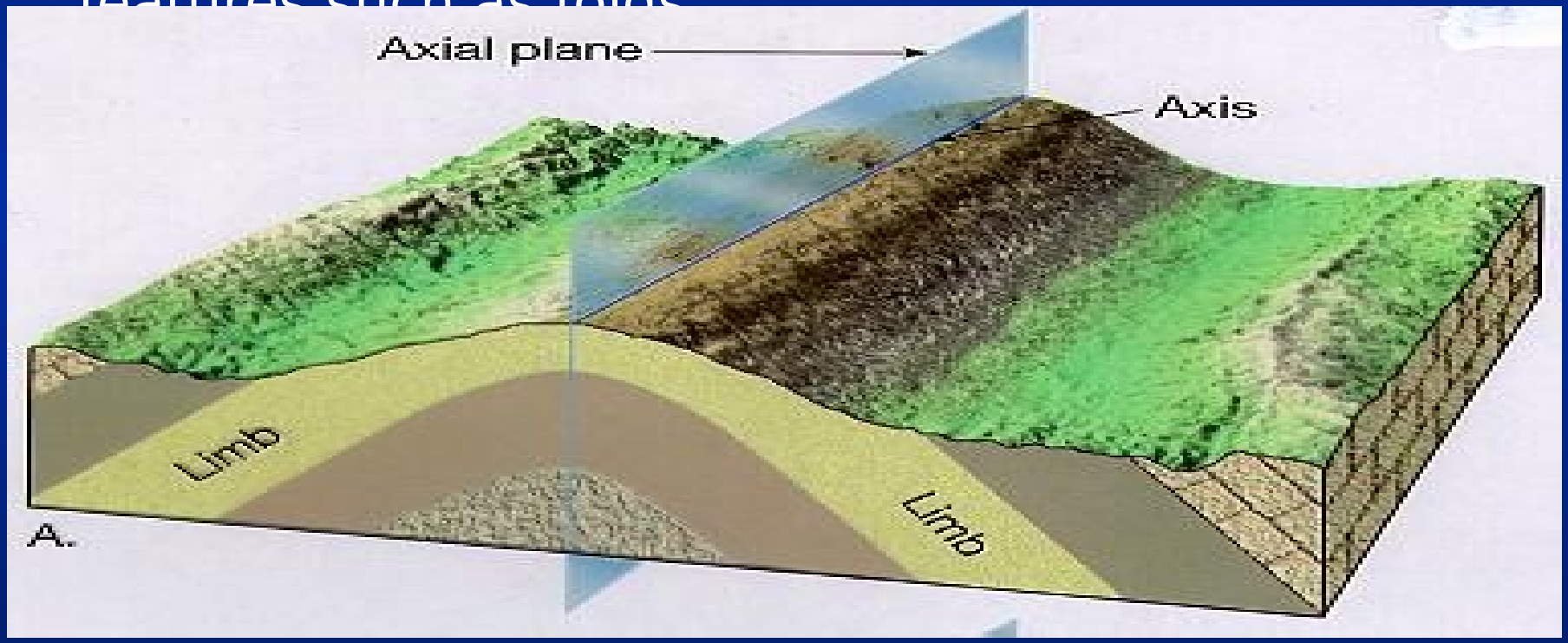
Geologic Structures..Folds

Rock layers are constantly undergoing stress, from the rocks above, from geothermal heat build-up, and from the motion of the earth's plates. As a result of these factors, they develop structural features such as folds.



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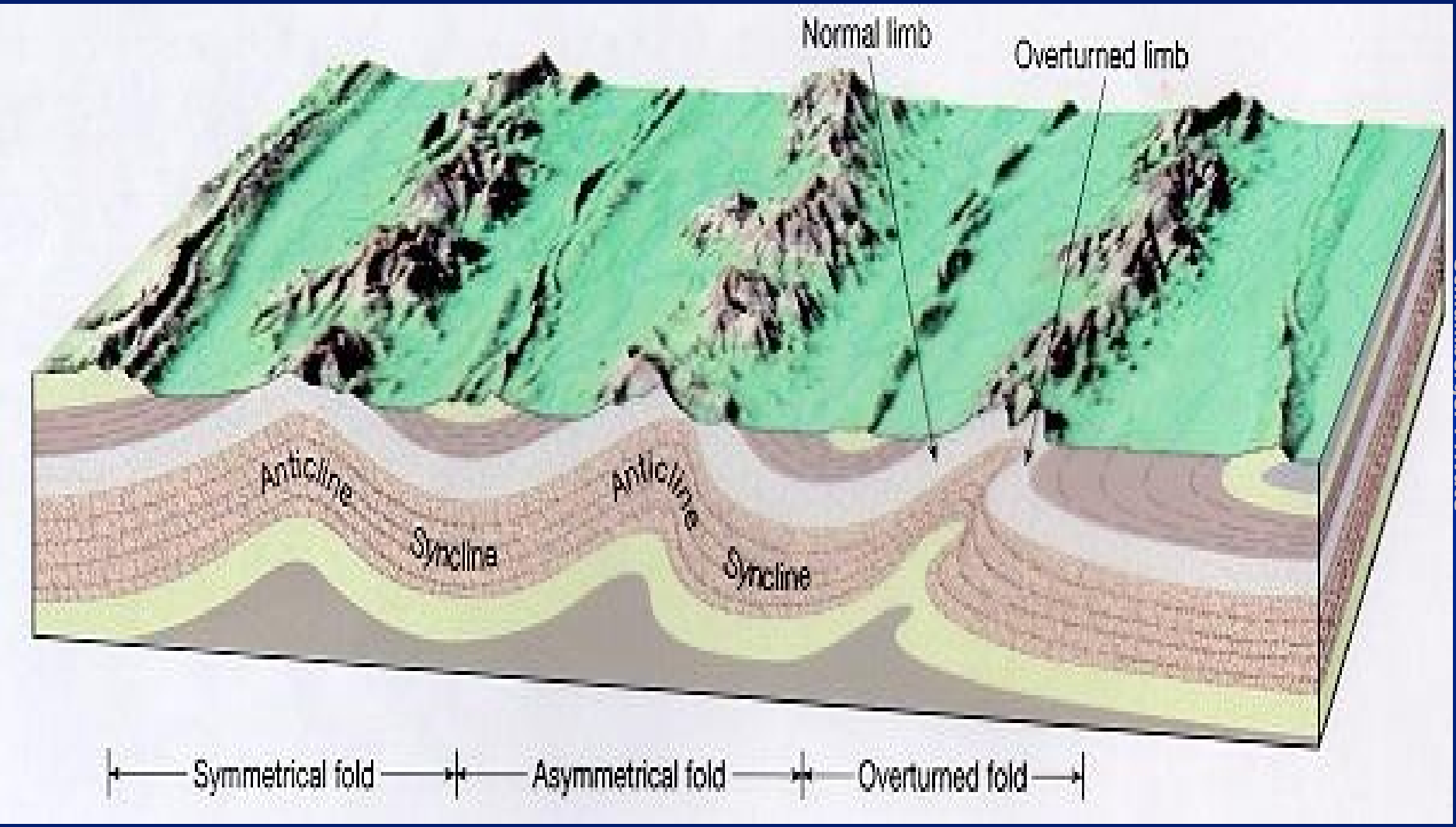
Types of folds



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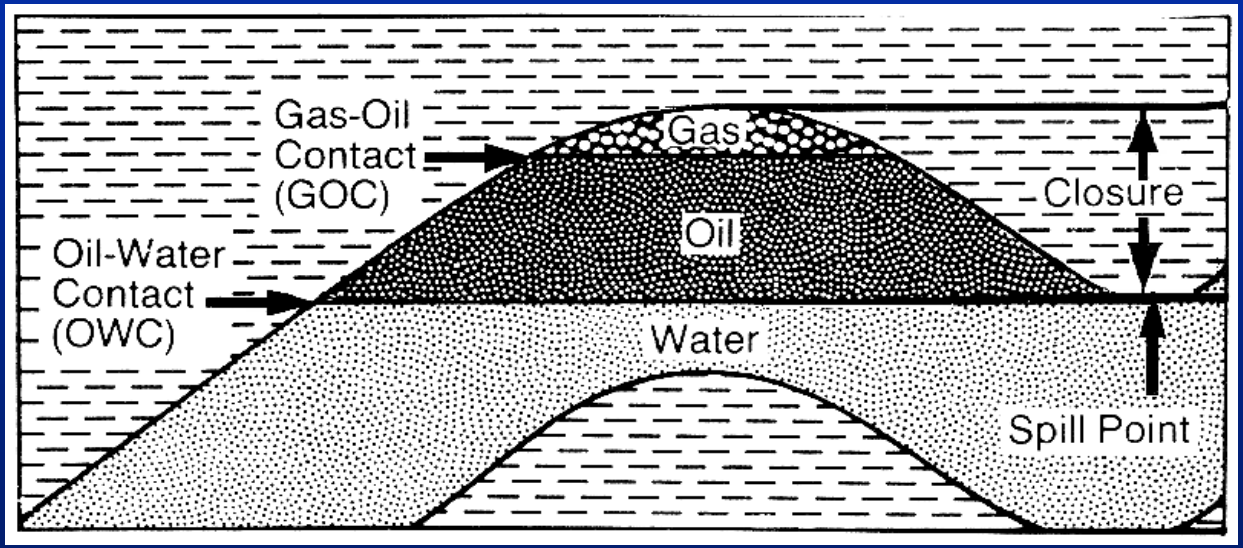
Structural Traps

A structural trap represents a trap that has resulted from the deformation of the rock, such as by folding or faulting.



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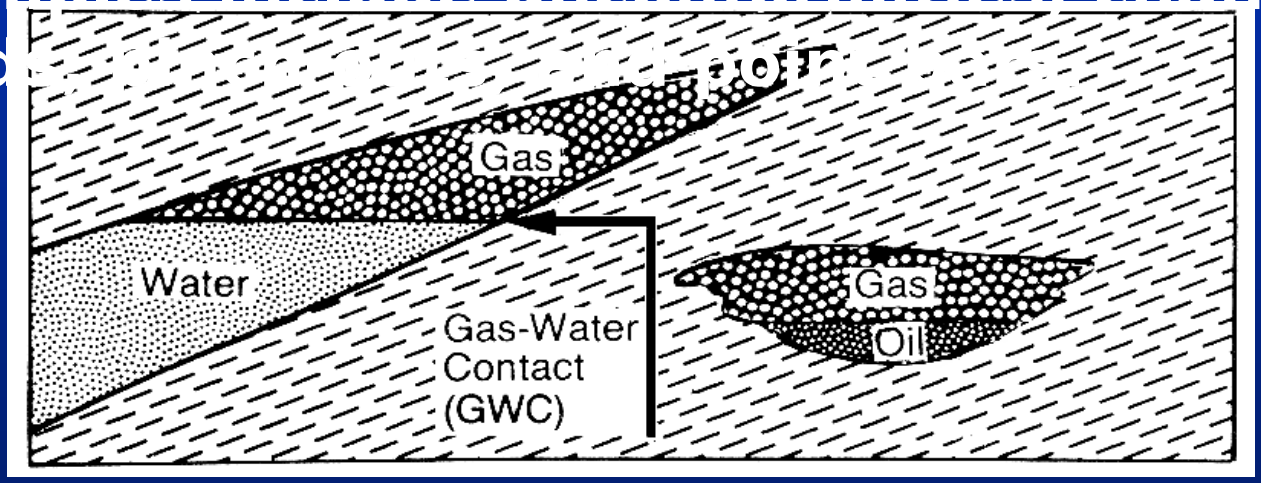
Stratigraphic Traps

Stratigraphic traps are those that are formed when the porosity or permeability has changed in the rock.

For example, a very permeable sandstone may become impermeable as it dips upwards. Examples include unconformities, channel sand



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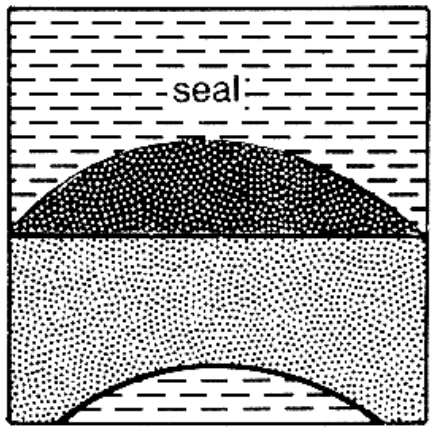
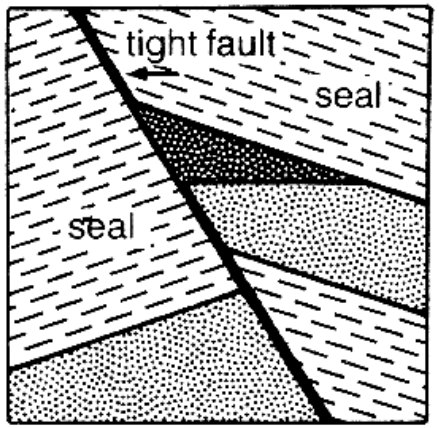
Various Traps

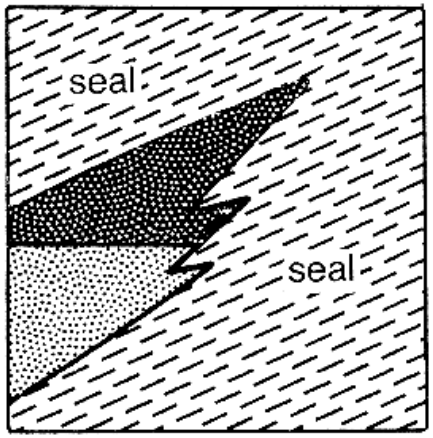
Lateral and vertical



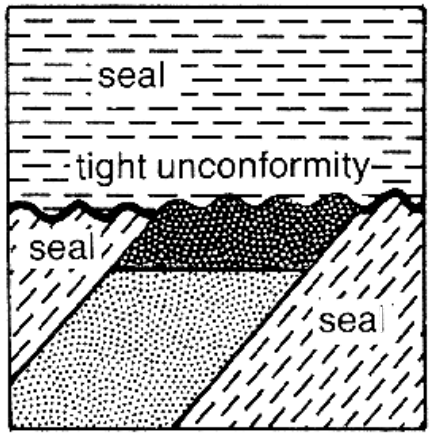
Anticline trap



Fault trap



Stratigraphic pinchout trap



Unconformity trap

Various types of traps

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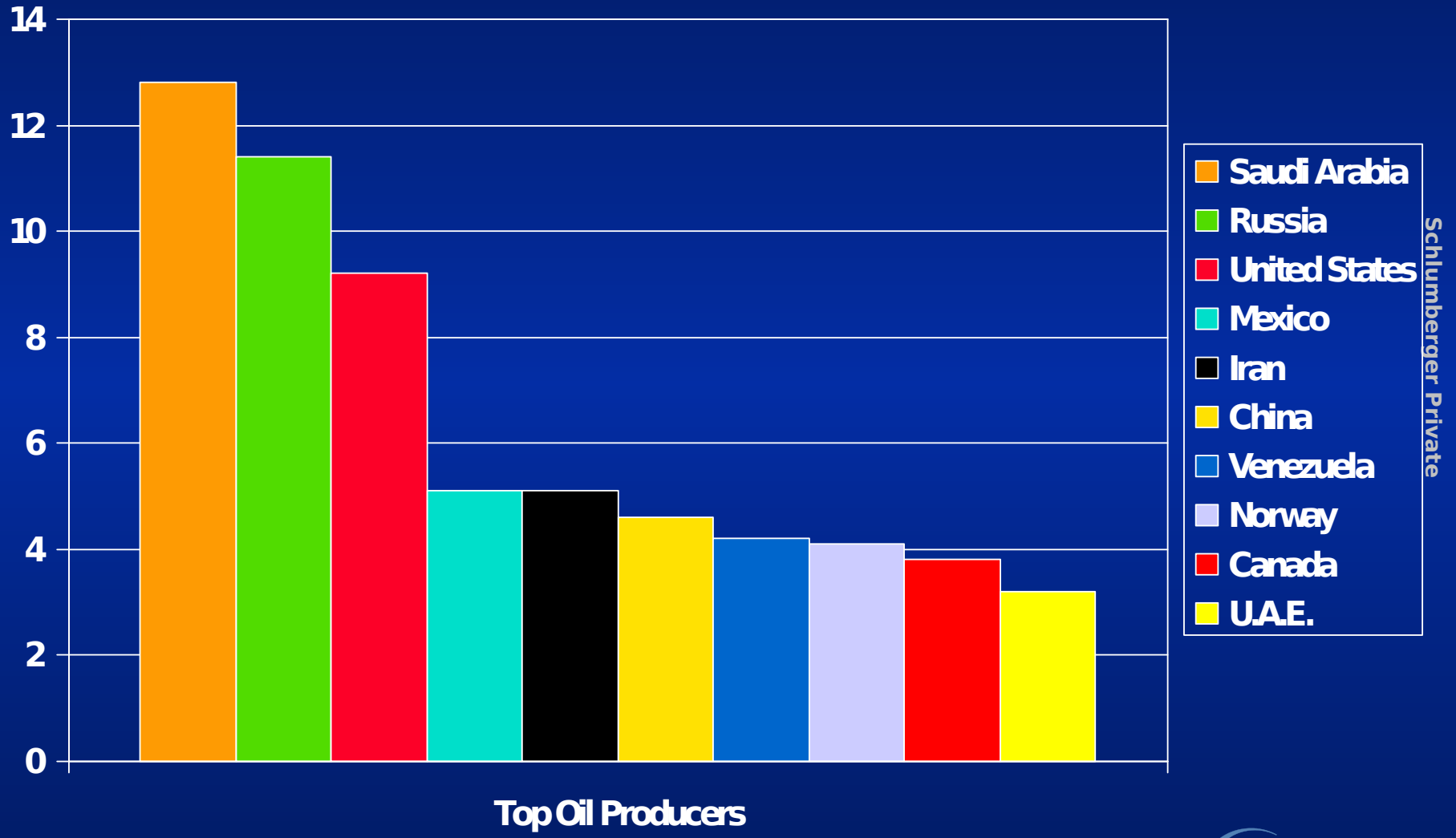
Ten Oil Producers 2003 % of total world producti



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